MACHINERY IN SIXTEENTH-CENTURY ENGLISH INDUSTRY

It is a common opinion that the introduction of machinery into manufacturing industry dates from the "industrial revolution" of the late eighteenth century, and that the application of power other than that of men and animals and the use of devices which may properly be termed machines were unknown before that time. While this belief is in general true, while no mechanical inventions of really revolutionary importance occurred before that time, it is nevertheless interesting to learn that there were, in the sixteenth century and earlier, many applications of "power" and many inventions of mechanical devices capable of tasks impossible to human labor alone, or at least so economizing human labor that they enabled one man to do the work of many.

The purpose of this paper is to give some account of the application of non-human sources of power to industrial processes in the sixteenth century, and of the various devices which made such application possible. In one or two cases pieces of mechanism are noted which depended on human labor for their motive power, but for the most part our attention is confined to power-driven machinery.

Among the oldest forms of the application of power to industry was the water-driven corn mill, the history of which would carry us back to Greek and Roman times. Whether the English borrowed their mills from those older nations or originated their own we do not positively know; but it is certain that water mills were used in England at an early date, and at the time of the Domesday Book there were thousands of them scattered over the kingdom.[1] It seems probable, too, that as early as this time water power was applied to other industries than the grinding of corn. Certain mills in Somerset paid their rent in metal, which would seem to indicate that they were used for the reduction of ore.[2] Bennett

[1] Bennett and Elton, *History of Corn Milling*, II, 101.

[2] *Ibid.*, II, 106–7.

and Elton in their *History of Corn Milling* conjecture that there were in use at this same early period the tanning mill, the paint mill, the sawmill, and the fulling mill, but there seems to be no very sound basis for this opinion.

The stream-side water mill has of course lasted to our own day, but rather as a picturesque bit of landscape than as a factor in practical industry. In the sixteenth century it was a factor of real importance, and as such received the attention of inventors. In 1565 we find the grant of a license to James Acontius (on whose advice the patent system was first applied to inventions) for the manufacture of machines for grinding.[1] It is possible, however, that Acontius' invention was intended, not to aid, but to compete with the water-power mill; for eight years later we find a grant to John Payne for twenty-one years of the privilege of the sole use of certain mills for grinding corn, these mills being "modified forms of hand and treadmills, examples of which had already been erected at Glastonbury."[2]

Another form of power often applied to the grinding of grain was the windmill. Mills of this kind are found from the year 1200 on. They were often built in conjunction with water mills, so that when one source of power failed the other might be utilized.[3] That windmills were extensively used in the sixteenth century is shown by an order of the Privy Council to the "Custumer" of Liverpool, October 28, 1555, instructing him to allow John Parker, Master of the Rolls in Ireland, to transport thither from Liverpool one hundred tons of timber for windmills to be set up in Ireland.[4] In 1588 one Robert Dell, lessee of a mill belonging to Her Majesty at Suffield, found occasion to complain to the Privy Council that Thomas Moore and others, seeking the undoing of Dell and the hindrance of Her Majesty's revenues, had erected mills in the vicinity, notwithstanding an order for the pulling down of a windmill which Moore had erected almost to the undoing of Dell. The Council thereupon ordered the proper authorities to see to it that

[1] E. W. Hulme, "History of the Patent System," *L.Q. Rev.*, XII, 148.

[2] *Ibid.*, XVI, 45.

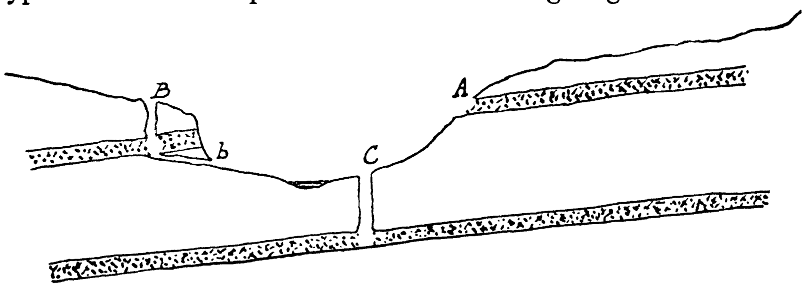
[3] Bennett and Elton, *op. cit.*, II, sec. 2.

[4] *Acts of Privy Council*, New Series, V, 189.

Her Majesty's revenues and the prosperity of Dell be no further interfered with by the erection of mills.[1]

A third frequent method of grinding grain was by horse-power, of which Bennett and Elton make frequent mention.[2]

A less venerable history than that of corn milling attaches to the use of machinery for the drainage of mines. It is in the coal mines that we find the first clear instances of the use of pumps and other draining devices, and even these occur for the first time long after the first chapters of the history of that industry had been written. The coal mining industry went through three well-defined stages, types of which are represented in the following diagram:



In the earliest stage, *A*, the coal vein was penetrated from the hillside, horizontally or at a slight upward angle. Here no machinery of any kind was required; the coal was carried out at the mouth of the tunnel and the water found its own way of escape. The second mine, *B*, is of the so-called "pit and adit" type. Here the vein is penetrated by a pit from above; the coal is raised by means of a windlass worked by human or horse power, and for purposes of drainage a tunnel or "adit" is driven from the bottom of the pit to an exit at some lower point, *b*. Up to near the end of the fifteenth century most of the coal mines in England were of these two types, depending for drainage upon gravity, though often by means of expensive tunnels. Toward the close of the century, however, coal miners on the Tyne and the Wear began to penetrate below the free drainage level, as at *C*, and it then became necessary to raise both coal and water by artificial means, usually by some

[1] *Ibid.*, New Series, XVII, 8.

[2] Bennett and Elton, *op. cit.*, IV, 44, 49, 92, 113, 127, 162, 175, 194.

horse-driven device.[1] As early as 1486 the monks of Finchale record the expenditure at Moorehouseclose of £9 15*s.* 6*d.* on a pump with house, fittings, and horses, and for some years special mention is made in their accounts of the expenses "de la pompe."[2] It is not till the second half of the sixteenth century, however, that we find such pumps, "gins," or baling engines in common use.[3]

In the tin mines[4] a similar cycle of changes took place, although apparently somewhat later. The point of revolution did not come till the sixteenth and seventeenth centuries. Then the depth of mines increased very rapidly, from an average of some thirty-six feet to a depth as great as sixty fathoms, at which point the crude drainage devices were taxed to the utmost. The wooden bowl in which at first the water had been carried out gave place to leathern bags or buckets, raised by a windlass. The latter was propelled at first by hand, later by horse power. A later device was the rag-and-chain pump, consisting of an endless chain broadened at intervals by leathern binding and fitting in a pipe from twelve to twenty-two feet in length. A mine of any depth of course required a series of such pumps, and as one four-inch pump twenty feet in length required five or six men at a time in six-hour shifts, the labor cost must have been heavy. Later the pumps were driven by water power, usually from a twelve- or fifteen-foot wheel. Just when these various improvements were introduced is largely a matter of conjecture. Mr. Lewis mentions a possible instance of the use of a hydraulic engine for draining tin mines in 1480, but concludes that the rag-and-chain pumps cannot be traced farther back than the seventeenth century.[5] Mr. Salzmann,[6] on the other hand, thinks their origin can be placed somewhat earlier: "a case of a London goldsmith making engines and instruments to drain a deep tin mine near Truro occurs in the first quarter of the sixteenth century."

[1] The foregoing account and diagram are adapted from R. L. Galloway, *Annals of Coal Mining*, p. 74.

[2] *Ibid.*, p. 71.

[3] Salzmann, *English Industries of the Middle Ages*, p. 9.

[4] G. R. Lewis, *The Stannaries*, pp. 9–11.

[5] *Ibid.*, p. 11.

[6] Salzmann, *op. cit.*, p. 86.

The high importance of machines for mine drainage is reflected in the large number of patents for such devices granted in the latter half of the sixteenth century. On December 31, 1562, John Medley was granted a twenty-year patent for an instrument "for the drayninge of water." It is stated "that mines of tin, lead, coal, etc., in Devon as elsewhere, were drowned and altogether unoccupied, 'owing to the great habundance of water.'"[1] In the next year, a similar license was granted to Burchsard Cranick to make engines for the draining of water. "The engine is stated to have been lately invented, lerned, and found out by Cranick, and to be unlike anything used or devised within the realm."[2] In July, 1565, a letter from William Humfrey to Sir William Cecil, concerning the working of the copper mines, "recommends an Almain engineer, who can raise water one hundred fathoms high, by a newly invented engine."[3] On April 20, 1569, there was granted to Daniel Heckstetter (or Houghstetter) a license "for setting up and using engines for mine drainage."[4] On October 28, 1573, Richard Candish received a twenty-year grant, extending over eight counties, for an engine for draining coal and iron mines.[5] A grant of April 25, 1598, to Edward Wright is interesting because of its wording. It confers upon the grantee, a Cambridge Master of Arts, the right for eight years "to make and utter mathematical instruments." The "mathematical instrument" in question is another water-draining device, obtained "by long and painful study of the mathematical sciences."[6] In the meantime we find a "description of . . . . pumps for raising water from mines, by Peter Jordayne and his coadjutors" in 1575,[7] and three years later a suit of Gherard Honricke, a native of West Friesland, for a patent giving him and his assigns for thirty years the "sole right to erect certain engines invented by him for the draining of mines."[8]

The various draining devices thus introduced seem to have been sufficiently effective to make possible the working of mines far

[1] Hulme, *op. cit.*, XII, 146. [2] *Ibid.*

[3] *Calender of State Papers*, Domestic Series, 1547–80, XXXVI, 73, p. 254.

[4] Hulme, *op. cit.*, XII, 149. [5] *Ibid.*, XVI, 46. [6] *Ibid.*, XVI, 51.

[7] *Cal. of State Papers*, Domestic Series, 1547–80, CVI, 24, p. 509.

[8] *Ibid.*, CXXV, 50, p. 598.

below former levels, and at the same time to have been so unreliable as to cause endless difficulties and annoyances. Thus, on July 24, 1584, Ulricke Frose reported to William Carnserve that the mines at Perin Sands "are at present fifty fathoms under all the old works";[1] while fifteen days later he reported from another mine at Treworthie that "the water has burst in upon them so suddenly that the men barely escaped with their lives."[2] Within a month he wrote again that the water continued so bad at Treworthie that unless rich silver ore were found the mining would not pay.[3]

These early inventions were of a primitive nature, and the same machine was often thought capable of draining mines and flooded lands, filling reservoirs for urban water supply, and extinguishing fire.[4] In 1571 a grant was made to Sir Thomas Goldinge for an engine for land drainage and water supply. "The engines, once erected, will continue working without man's labor."[5] Probably these engines were water-driven. An even greater diversity of use is indicated in a petition of the same Sir Thomas Goldinge in 1578 for "the sole right to an invention designed by him for draining of marshes, supplying of towns with water, and working of mills."[6] Another instrument, for which John Symetson received a grant in 1573, was designed for land drainage and for the stopping of breaches in dams.[7]

The frequent mention of machines for the drainage of land calls attention to the persistent efforts being made for the drainage of the Fens, the marsh lands of the eastern counties, particularly around Ely. For the most part this work was undertaken by means of ditches and canals, references to which are scattered through the acts of the Privy Council in the latter half of the sixteenth century. But there were also attempts to perform the work by machinery. In 1575 Peter Morris (or Morrice), a Dutchman, had petitioned for a patent for "the sole right of making

[1] *Cal. of State Papers*, Domestic Series, 1581–90, p. 191.

[2] *Ibid.*, p. 194.

[3] *Ibid.*, p. 200.

[4] W. R. Scott, *Joint Stock Companies*, II, 479.

[5] Hulme, *op. cit.*, XVI, 45.

[6] *Cal. of State Papers*, Domestic Series, 1547–80, CXXVII, 57, p. 611.

[7] Hulme, *op. cit.*, XVI, 46.

and employing certain hydraulic engines for the raising of water, draining marshes, etc."[1] In June, 1580, we find a letter from the Privy Council to the Bishop of Ely and others, mentioning that Her Majesty had by letters patent licensed one Peter Morris to drain certain fens and low grounds "by certain engines and devices never knowen or used before"; that these had been put in practice by George Carlton and Humfrey Michell, "unto [whom] the said Peter Morris for want of habilitie had conveyed over his said Letters Patent"; and that the works were likely to prove very beneficial, but were greatly hindered by lack of funds.[2]

The name of Peter Morris is much more famous for his connection with another enterprise, the establishment of the London Bridge Water Works. For an annual payment of 10*s*. Morris received from the Mayor and Commonalty of London a five-hundred-year lease, by which he was authorized to erect an engine under the first arch of London Bridge to supply the city with water.[3] The city was to pay £100 and furnish the land for his works.[4] In 1580 or 1581 Morris made complaint to the Privy Council that the city refused to stand by its part of the agreement, after he had been at great expense to make preparation, because (supposedly) some other person had offered to furnish water at less cost. The Council could not see why the city should not fulfil its contract, and required it to do so unless it could show some stronger reason to the contrary.[5] The work continued, and by the year 1582 the new engine was in operation. Within two years another lease was granted for the use of the second arch.[6]

The machinery consisted of a water wheel nineteen or twenty feet in diameter and fourteen feet in length, carrying twenty-six eighteen-inch paddles which dipped into the current where it was confined between the piers of the bridge. Each wheel, by a system of gearings and levers, operated sixteen seven-inch cylinders of the

[1] *Cal. of State Papers*, Domestic Series, 1547–80, CVI, 62, p. 512.

[2] *Acts of the Privy Council*, New Series, IX, 689.

[3] W. Matthews, *Hydraulia*, pp. 25–27.

[4] *Acts of the Privy Council*, New Series, XII, 85–86.

[5] *Ibid.*

[6] Matthews, *op. cit.*, pp. 26–27.

force-pump type. When the force of the falling tide was added to the natural flow of the river the wheel made six revolutions a minute, producing 684 piston strokes, and raising 1,954 hogsheads of water in an hour. Stow recorded (1663) that in his exhibition before the mayor and aldermen of London Morris threw water over St. Magnus' steeple.[1]

As suggested by his complaint to the Privy Council, Morris was not free from competition. In 1594 a large horse engine was erected by Bevis Bulmar at Broken Wharf to supply water for the west side of the city of London. Expenses were so heavy, however, that Bulmar could not compete with other establishments, and the project had to be abandoned.[2]

The British government was troubled not only with freeing the marsh lands from water, but also with keeping the harbors clear of sand. To this work also machinery was applied. In 1558 George Cobham, Tomazo Chanata, and others petitioned the Queen "for the sole use of an engine to cleanse and carry away all shelves of sand, banks, etc., out of all rivers, creeks, or havens."[3] On May 26, 1562, the patent was granted to George Cobham for ten years. The patentee represented that "by diligent travel" he had discovered a machine which would scour the entrances to harbors to a depth of sixteen feet. The patent was for the importation of a sufficient number of these machines.[4]

We have seen that water power was applied very early in England in the grinding of corn, and that there is some reason to suspect that it had other uses as early as the eleventh century. By the opening of the fifteenth century the use of water power in connection with blast furnaces for the reduction of iron ore had become fairly common, and from that time on grew in importance. The early iron smelters had been as shrewd in utilizing natural forces for securing draft as the early miners had been in securing drainage. In Roman times, and probably for long after, the practice was to build the furnace on a wind-swept hill with a tunnel flaring to the west and tapering to the hearth in such a way as to catch and con-

[1] Matthews, *op. cit.*, pp. 27–29. [2] *Ibid.*, p. 30.

[3] *Cal. of State Papers*, Domestic Series, 1547–80, I, 56, p. 119.

[4] Hulme, *op. cit.*, XII, 145.

centrate as much as possible the full force of the prevailing westerly winds. This method was probably supplemented at an early date by the use of bellows. Prior to the fifteenth century such bellows were worked by hand, "or rather by foot, for the blowers stood upon the bellows, holding onto a bar, but during the fifteenth century water power was introduced in many parts of the country, and the bellows were driven by water wheels."[1] One of the earliest examples of the application of water power to a blast furnace was Bishop Langley's furnace in Durham, run by John Dalton, the records of which for the years 1408–9 are preserved. "At the bishop's forge we hear of the making of a 'watergate' and a water-wheel . . . ., but it is doubtful whether water power was always applied for working the bellows, as the wife of the 'blomesmyth' is not only mentioned as 'folles sufflans,' but also on occasion 'operariis auxilians ad le belowes.' "[2] "Probably when there was an insufficiency of water or any defect in the mechanical connections resort was had to the older foot blast,"[3] although Mr. Lapsley thinks that the smith's wife was employed merely to make adjustments in the crude connections between the water wheel and the bellows.[4]

From several different sources we get descriptions of the iron furnace and water-power bellows. The furnace was a building some twenty-four feet square and twenty-six to thirty feet high, containing an egg-shaped cavity at the bottom of which was a sandstone hearth with an iron vent for the bellows.[5] "Behind the furnace are placed two high pair of bellows, whose noses meet at a little hole near the bottom; these are compressed together by certain buttons on the axis of a very large wheel, which is turned round by water in the manner of an overshot wheel. As soon as these buttons are slid off, the bellows are raised again by a counter-poise of weights, whereby they are made to play alternately, the one giving its blast whilst the other is rising."[6] In some cases, on

[1] Salzmann, *op. cit.*, pp. 26–27. [2] *V.C.H.*, Durham, II, 279, note.

[3] *Ibid.*, II, 354.

[4] G. T. Lapsley, "The Account Roll of a Fifteenth Century Iron Master," *Eng. Hist. Rev.*, XIV, 513.

[5] *V.C.H.*, Sussex, II, 244.

[6] Lapsley, *loc. cit.* The description is of a seventeenth-century furnace, but is probably not misleading if applied to the sixteenth century.

the Continent at least, wooden bellows—great wooden pistons working in tubs—were substituted for the old bellows of leather. The invention of wooden bellows is ascribed to Germany and the sixteenth century; it seems clear that by 1550 both wooden and copper bellows were in use in that country.[1] I have found no evidence of the use of either in England.

An incident of 1500 illustrates the importance at that date of water power in the iron industry. In that year Thomas Luke, bailiff of Chesterfield and Scarsdale, was tried in the Duchy of Lancaster Court for various trespasses. It was charged that he "hath turned the water which served the said mill [a mill of the king's] out of the old right course into his own proper ground, whereupon he hath made smithies to make iron with."[2]

Water power was utilized not only in reducing iron from the ore, but also for driving the hammer by which it was brought into commercial shape. The date of the introduction of such water hammers is uncertain, but there is an instance of a "great water-hamor" working in Ashdown Forest, Sussex, in 1496.[3] The forge, iron mill, or hammer was a building containing two open hearths, the "finery" or "chafery," and the hammer proper, which weighed seven or eight hundred pounds. The rough "sow" was carried from the furnace to the hammer, "under which they, then removing it, and drawing a little water, beat it with the hammer very gently, which forces cinder and dross out of the matter; afterwards by degrees drawing more water, they beat it thicker and stronger until they bring it to a *bloom*, which is a four-square mass of about two feet long."[4]

By the close of the sixteenth century such hammers were very common. "I have heard," said John Norden in 1607, "there are or lately were in Sussex neere 140 hammers and furnaces for iron."[5] Camden (1551–1623) says that in Sussex "the heavy forge-hammers which were mostly worked by water power, ... beating upon the iron, 'fill the neighborhood round about, day and night, with continued noise.' "[6]

[1] Beckmann, *History of Inventions and Discoveries*, I, 108.

[2] *V.C.H.*, Derby, II, 245.

[3] Salzmann, *op. cit.*, 30, note 1.

[4] *V.C.H.*, Sussex, II, 245.

[5] *Ibid.*, II, 247.

[6] Swank, *Iron in All Ages*, p. 46.

The history of the reduction of tin, lead, and silver from their ores follows substantially the same lines as that of iron. In the case of these metals the ore was frequently put through some kind of stamping process to prepare it for the furnace. There is no good evidence of the use of such mechanical stamps earlier than the sixteenth century, "though there is mention in 1302 of a machine (*ingenium*) for breaking 'black work' or slag."[1] Carew has left us a brief account of the treatment of tin ore in 1602. The ore was first broken with hammers, and then carried on horse or cart to "a stamp mill of three or sometimes of six iron-shod heads, driven by a water-wheel."[2]

The actual smelting of lead, silver, and tin went through exactly the same stages as that of iron. At first the furnaces or "boles" were placed on a hilltop, and depended entirely upon the wind for their draft. At an unknown date these furnaces came to be supplemented by "slag-hearths" or furnaces with artificial draft. The bellows were originally driven by the feet, but water-power bellows were used in Devon as early as 1295, "and at Wolsingham in Durham, in 1426, water power was used when available, the footblast being used during dry seasons."[3] Sometimes a lead furnace was supplied with all three kinds of draft—wind, water, and foot power—so that if one source failed another could be utilized.[4] An account of a furnace of some lead smelters at Wicksworth in 1729, while of a far-removed date, enables us to form a probably accurate picture of the furnaces of the sixteenth century. This furnace is described "as very rude and simple, consisting only of some large, rough stones placed in such a manner as to form a square cavity, into which the ore and coals are thrown stratum super stratum, two great bellows continually blowing the fire, being moved alternately by water."[5]

In the tin industry the "blowing house" was in common use by the middle of the fourteenth century. "Here the prepared ore was made into parcels according to its quality, and then smelted on the hearth of the granite furnace by a charcoal

[1] Salzmann, *op. cit.*, p. 51.

[2] Lewis, *op. cit.*, p. 15.

[3] Salzmann, *op. cit.*, p. 52.

[4] *V.C.H.*, Durham, II, 350.

[5] *V.C.H.*, Derby, II, 329, note.

fire fed by a blast from a large pair of bellows worked by a water wheel."[1]

Turning from the reduction of metal from the ores to its manufacture, we find that the most important introduction of mechanical power occurred between 1565 and 1568, in the manufacture of wire. Previous to 1568, says Camden, all iron wire made in England was drawn "by main strength alone."[2] The introduction of machinery into the process seems to have been due to the arrival in England in 1565 of Christopher Schutz of Saxony.[3] Schutz came at the invitation of William Humfrey, assay-master of the Tower Mint, and before the year was out Humfrey, Schutz, and others had secured a patent to set up battery works for drawing wire. The syndicate had undertaken to provide twenty foreign workmen and to draw iron wire by mechanical power with the assistance of a water mill.[4]

Another invention of the late sixteenth century which it seems safe to suppose made use of mechanical power was the slitting mill, "an invention for slitting flattened bars of iron into strips called nail-rods." It is recorded that the first mill of the kind was set up at Dartford in 1590 by Godfrey Bochs of Liège, Belgium.[5]

In the textile industry, so important in England from the fourteenth century on, there was almost no use of machinery except in a single process, that of fulling. The spinning and weaving processes seem to have undergone no change of importance during many centuries. As far as mechanical processes were concerned, they were substantially the same on the brink of the industrial revolution as in the time of Edward III. There was one important invention in knitting, the stocking frame, which was patented by its inventor, Lee, in 1589,[6] but was carried to France because of the refusal of adequate protection in England.[7] Another textile invention, which apparently was put into application, was a mill for the preparation of hemp for the weaving of linen cloth.

[1] Lewis, *op. cit.*, p. 17.

[2] Swank, *op. cit.*, p. 48.

[3] *V.C.H.*, Surrey, II, 410–11.

[4] Scott, *op. cit.*, II, 413–14.

[5] Swank, *op. cit.*, p. 48.

[6] *V.C.H.*, Derby, II, 367.

[7] Hulme, *op. cit.*, XVI, 53. Another invention that failed for want of adequate protection in the last decade of the century was Harrington's water closet (*ibid.*, p. 53).

In the *State Papers* of 1561 we read of "'a lyttle booke, entituled a profitable Newyeres Gifte to all Englande,' being a small printed tract of a device by Thomas Trollope for the setting up 'of a mille to knocke hempe for the making of canvas and other linnen clothes.' "[1] A little later we find a second mention of the hemp mill. The aldermen of Stamford "have conferred with Thomas Trollope touching the manufacture of canvas. The mill for beating of hemp will cost 50 *l*. They purpose to begin on a small scale at first."[2] With these two brief notices the hemp mill drops into obscurity.

In the fulling process alone in the textile industry do we find evidence of the extensive use of machinery. Here it is widespread and of early origin. The process of fulling is described by Mr. Salzmann: "Raw cloth had next to be fulled, that is to say, scoured, cleansed, and thickened by beating it in water. Originally this was always done by men trampling upon it in a trough, and the process was known as 'walking' (whence the common surname) but during the thirteenth century an instrument came into general use called 'the stocks,' consisting of an upright, to which was hinged the 'perch' or wooden bar with which the cloth was beaten. The perch was often worked by water power, and fulling or walking[3] mills soon became common."[4]

Fulling mills seem to have been antedated by the grinding of corn alone in their utilization of water power. In Lancashire there is mention of a fulling mill in 1282. A survey of the county in 1320 reported that there was "a certain fulling mill running by the stream of the Irk." There are other references to mills in 1295 and 1296.[5] The fulling mills in Surrey "have been said to have been among the first in the kingdom. Water power for them could be readily obtained from the small rivers and streams which passed through the heart of the county."[6] In Warwickshire also the fulling

[1] *Cal. of State Papers*, Domestic Series, 1547–80, XVII, 49, p. 119.

[2] *Ibid.*, XVIII, 23, p. 180.

[3] Probably the "walking-beam" of an early type of steam engine took its name from the similarity of its function to that of the "perch" or horizontal beam of the walking mill.

[4] *Op. cit.*, pp. 153–54.

[5] *V.C.H.*, Lancashire, II, 376.

[6] *V.C.H.*, Surrey, II, 342.

mills apparently depended upon water power, for we are told that "in Coventry, as elsewhere, the fulling mill was always to be looked for near a running stream."[1]

The application of water power to the fulling process brought about such an economy of labor that town fullers found it advantageous to send out their cloth to be fulled at water mills. Thus about 1297 the fullers of London were sending their cloth to be fulled at the mills of Stratford. This practice, however, was found to be injurious to the cloth, and was forbidden except with the express consent of the owners of the cloth.[2] Salzmann concludes from this fact that either fulling by mill was inferior to hand fulling or else the escape from city control in the process tended to bad work. It seems not unlikely that the reduced demand for labor resulting from the resort to the mills may have helped to bring about the prohibition.

Before the end of the fourteenth century, however, the fullers of London were firmly established in the practice of sending out their cloth to be fulled at water mills, not only at Stratford, but also at Wandlesworth, Old Ford, and Enfeld.[3] In 1376 three London fullers, Oliscompe, Suttone, and Swift, filed a petition with the mayor and aldermen, complaining that the "hurers" or cappers of the city were making a practice of sending their caps and hures[4] to the above mills, where the fullers were accustomed to full their cloth, with the result that when the caps were mixed with the cloth in fulling, "such caps crush and tear the cloths, to the great damage and loss, as well of the said fullers as of all the community."[5] In the same year the hurers of the city themselves complained that some of the trade had provided a water mill for fulling caps and hures in the same manner as cloth; "whereby such caps and hures are not so good and so profitable for those who buy and use them, nor of such good fashion, as they were wont to be, to the great damage of the common people; and that the said simple folks of the said trade have no work to maintain and aid them; insomuch that they are so greatly impoverished, that they are at the point of

[1] *V.C.H.*, Warwick, II, 252.

[2] Salzmann, *op. cit.*, pp. 153–54.

[3] Riley, *Memorials of London*, p. 401.

[4] A "hure" was a shaggy cap.

[5] Riley, *loc. cit.*

perishing, if they be not succoured; the same being in deceit of the people, and to the annihilation of such trade."[1] Here is the typical attitude of laboring people toward labor-saving machinery, though it seems quite probable in this case that there was reason for complaint of the quality of the work produced by the mills.

The mayor and aldermen called before them those against whom the charges were made; "and these last acknowledged the deceit and damage in the things aforesaid alleged against them, and conceded that they would not henceforth full at the said mill." The mayor and aldermen thereupon granted an ordinance to the effect that no one of the trade should thenceforth full any hures or caps at the mill.[2] This prohibition was re-enacted in 1404 at the petition of the hurers and cappers,[3] and in 1418 one Thomas Tailor was fined and made to forfeit a number of caps for having fulled them at a mill.[4] Finally the matter was treated by parliamentary legislation. In 1482 a statute was passed prohibiting the fulling or thicking of hats or bonnets in fulling mills, on the ground that such practice threw many out of employment and resulted in hats and caps being "broken and deceitfully wrought."[5] I have found no later reference to the fulling of hats and caps in fulling mills.

A few references are found to mills of other kinds. Unfortunately we cannot be sure whether the term "mill" always implies the use of power machinery. It seems reasonably safe in most cases, however, to assume that when the term is used it has reference to the application of some kind of power, most frequently water power. This is evidently true of the account of brazil mills in Surrey County. These brazil mills were mills used for grinding and preparing dye-woods, "of which there seem to have been no small number along the course of the little river Wandle." A brazil mill at Wandsworth is referred to in the church warden's accounts for that parish in 1571. On the same river in Wimbledon was a mill used for both a fulling and a brazil mill.[6]

[1] Riley, *op. cit.*, pp. 402–4.

[2] *Ibid.*, *loc. cit.*

[3] *Ibid.*, pp. 558–59.

[4] *Ibid.*, p. 667.

[5] *Statutes of the Realm*, II, p. 473, 22 Ed. IV, c. V.

[6] *V.C.H.*, Surrey, II, 366–67.

Less clear is the case of a paper mill erected in 1588 near the town of Dartford by John Spilman, a High German, and said to be the first of the kind in England.[1] No mention is made of power or of stream-side location, but it seems not unreasonable to suppose that the mill was dependent on water power.

The foregoing account seems practically to exhaust the list of mechanical appliances of any importance used or invented in the sixteenth century. Much of the material comes from dates earlier than that century, but it can be assumed that any machine of the fourteenth century, for instance, which proved of value and was not replaced by better, continued in use in the sixteenth. The last half of that century was comparatively prolific in inventions. None of these, however, thinks Mr. Price, proved of first-rate importance. In origin, they were due rather to the industrial expansion of the period than to the influence of government patents, and both the accounts of mining and the patent rolls show that most of the improved appliances were introduced from Germany. On the whole, they represent on the part of the English a fair amount of mechanical ability, some ingenuity, and considerable teachableness.[2]

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[1] Scott, *op. cit.*, I, 116.

[2] W. H. Price, *English Patents of Monopoly*, pp. 62–63.